Thermal Characteristics of Sn-Mo Anodes for Lithium Batteries

L. Christensen , J. Landucci, J. Cross, R.L. Turner, L.J. Krause and J.R. Dahn[a]

3M Co., 3M Center, St. Paul, MN, 55144-1000, USA
a - Depts. of Physics and Chemistry, Dalhousie University, Halifax, N.S., Canada B3H 3J5

In two previous talks at this meeting the structural and electrochemical characterization of Sn-Mo films has been presented. In these presentations, we have attempted to show that we selected an anode material that will give higher energy with acceptable cycle life. However, there are two key requirements of an advanced lithium ion battery, significantly higher capacity/energy and improved safety. Safety issues are often times complex and become increasingly more important to address as the energy of the battery increases. To further evaluate the Sn-Mo materials the electrochemical and thermal performance in 18650 cells was studied.

Safety concerns for Li-ion cells pertain to thermal runaway that may occur during abuse conditions such as short circuit, nail penetration, high temperature exposure, and overcharge. Such runaway will result in venting and/or flaring. It is well established from ARC measurements that exothermic behavior is observed from both the anode as well as the cathode in contact with electrolyte (1,2). The onset temperature for sustained self-heat is 80°C for composite graphite anodes [2].

Figure 1 shows the onset of sustained self heat of a fully lithiated MCMB 10—28 graphite anode and a fully lithiated Sn-Mo anode in contact with EC/DEC 1M $LiPF_6$ electrolyte. The ARC sample sizes were adjusted to contain the same amount of active Li. We observe the earlier reported onset of sustained self-heat at 80°C for composite graphite (2) while the onset of self-heat for the thin film anode at 200°C coincides with the onset temperature of the electrolyte itself. Thus ARC results suggest that the stability of the Sn-Mo is greatly improved in comparison to graphite. The results of oven exposure tests at 150°C are shown in Figure 2 and were performed on a fully charged fresh 1400mAh commercial cell and a fully charged fresh 1740mAh Sn-Mo cell. Both cells were tested “naked” i.e. without a label wrap (3). The commercial cell goes into thermal run-away after 12 min at 150°C, whereas the Sn-Mo cell only displays a slight exotherm raising the surface temperature of the cell to 152.7°C. This class of material possesses remarkable safety characteristics exhibited in both ARC measurements and oven exposure tests. The improvement in safety makes these materials attractive for use with higher capacity cathode materials such as $LiCo_{0.2}Ni_{0.8}O_2$.

Calculated capacities and energies in 18650 cells show that with the Sn-Mo materials a 2 to 2.7 Ah 18650 cell is possible. It is reasonable to project a 50 % improvement in capacity and 35 % improvement in volumetric energy in 18650 cells with the Sn-Mo anode materials over currently available cells (4). 18650 cells with 1700 mAh demonstrated 80 cycles, and are in good agreement with the results from coin cells and 18650 cell calculations.

References

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Figure 1. ARC test showing sustained self heat of a fully lithiated MCMB 10—28 graphite anode and a fully lithiated Sn-Mo anode in contact with EC/DEC 1M $LiPF_6$ electrolyte.

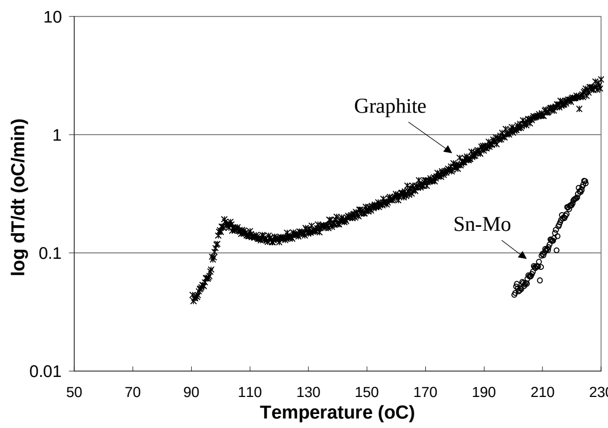

Figure 2. Oven exposure tests at 150°C showing thermal runaway in a 18650 commercial cell and 3°C self-heating in a Sn-Mo 18650 cell.